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Publications of the Exobiology Program for 1991

A Special Bibliography

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Introduction

The Exobiology Program, located within the Solar System Exploration Division, Office of Space Science and Applications of the National Aeronautics and Space Administration, is an integrated program designed to investigate and understand those processes related to the origin, evolution, and distribution of life in the universe.

This report contains a listing of 1991 publications resulting from research supported by the Exobiology Program. Our intent in compiling this bibliography is twofold: to provide the scientific community with an annual publication listing (as we have done since 1975) of current NASA-supported research in this field, and to stimulate the exchange of information and ideas among the scientists working in the different areas of the program.

The Exobiology Program is broad in scope, covering the following subject areas: **Cosmic Evolution of Biogenic Compounds, Prebiotic Evolution, Early Evolution of Life, Evolution of Advanced Life, Solar System Exploration, Exploration Exobiology, Search for Extraterrestrial Intelligence, and Planetary Protection.**

Cosmic Evolution of Biogenic Compounds focuses on understanding the cosmic history of the biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and early solar system and understanding the mechanisms of their incorporation (evolution) into organic compounds. This includes: (1) tracing the physical and chemical pathways of the biogenic elements and their compounds from their origins in stars to their incorporation in pre-planetary bodies; (2) determining the kinds of measurements that can be made on the biogenic elements and their compounds to develop theories about solar system formation and prebiotic evolution, and the origin of life; and (3) determining the ways in which the physical and chemical properties of the biogenic elements and their compounds may have influenced the course of events during the formation of the solar system and component bodies.

Prebiotic Evolution seeks to understand how the evolutionary sequence leading from simple chemicals to living systems occurred during the development of the Earth and other planets. Research and analysis falls into two major areas: (1) the consequences of planetary evolution on the physical environment of the Earth and planets, including the importance of the physical-chemical processes associated with the development of dynamic planetary surfaces, and (2) the evolution of molecules and molecular systems focusing on energetics, dynamics, and synthesis of chemicals and chemical systems to determine mechanisms by which these systems acquired biological attributes under the constraints imposed by the physical environment.

Early Evolution of Life focuses on the nature and history of primitive organisms, relating their evolution to those forces that shaped the evolution of the Earth. The evolutionary record occurs in two forms: the familiar fossil record in rocks, in which phylogeny is deduced from morphology, and in the genome of extant organisms, where mutational events, the driving force of evolution, are expressed in sequences found in the organism's nucleic acids, or the gene products. Thus, studies use the geological record and the molecular record in living organisms to determine when and in what setting life first appeared, to determine the characteristics of the first successful living organisms, to understand the phylogeny and physiology of primitive organisms, to understand the evolution of energy-transducing systems, and to understand what determines the rate of mutation (evolution).

Evolution of Advanced Life examines the influence of astrophysical, stellar, and solar system impact events on the evolution of advanced life on Earth, with specific regard to their role in species extinctions. Research in this area focuses on understanding the role of extinction in evolution and the physical conditions that cause extinction of species.

Cosmic Evolution of Biogenic Compounds

Allamandola*, L.J.
Analysis of frozen volatiles.
In: *ROSETTA/CNSR: A Comet-Nucleus Sample-Return Mission*. Paris: European Space Agency, p. 47-52, 1991. (ESA-SP-1125) (GWU 14444)

Allamandola*, L.J.
Interstellar organics and possible connections with the carbonaceous components of meteorites and IDPs (Abstract).
Meteoritics 26(4): 312-313, 1991. (GWU 15914)

Allamandola*, L.J.
The nature of interstellar/precometary ices.
In: *The Physics and Composition of Interstellar Matter* (Krelowski, J., Papaj, J., Eds.). Torun: Copernicus University Press, 1990.

Allamandola*, L.J.; Sandford, S.A.; Tielens, A.G.G.M.; Herbst, T.
Methanol in the sky with diamonds (Abstract).
Meteoritics 26(4): 313, 1991. (GWU 15913)

Allamandola*, L.J.; Sanford, S.A.; Schutte, W.A.; Tielens, A.G.G.M.
Laboratory and observational study of the interrelation of the carbonaceous component of interstellar dust and solar system materials (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 18, 1991. (NASA-CP-3129) (GWU 5894)

Anicich*, V.G.; Arakelian, T.; Hanner*, M.S.
Quantification of UV stimulated ice chemistry: CO and CO₂ (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 19, 1991. (NASA-CP-3129) (GWU 6495)

Banin*, A.; Blake*, D.F.; Benslomo, T.
Detection of nanophase lepidocrocite (γ -FeOOH) in iron-smectite Mars soil analog materials (MarSAM) (Abstract).
Lunar and Planetary Science Conference XXII: 49-50, 1991. (GWU 15710)

Baron, R.; Joseph, R.D.; Owen*, T.; Tennyson, J.; Miller, S.; Ballester, G.E.
Imaging Jupiter's aurorae from H₃⁺ emissions in the 3-4 μ m band.
Nature 353(6344): 539-542, 1991. (GWU 11099)

Batillo, F.; LeRoy, R.C.; Parvin, K.; Freund*, F.; Freund, M.M.
Positive holes in magnesium oxide: Correlation between magnetic, electric, and dielectric anomalies.
Journal of Applied Physics 69(8): 6031-6033, 1991. (GWU 14875)

Batillo, F.; Desgranges, L.; Freund*, F.
Anomalous thermal expansion and large polaron conductivity in magnesium oxide single crystals (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 529-530, 1991. (GWU 16095)

Bergin, E.A.; Goldsmith, P.F.; Snell, R.L.; Ungerechts, H. (Irvine, W.M. = P.I.)
Physical conditions along the Orion Molecular Cloud ridge (Abstract).
Bulletin of the American Astronomical Society 23(4): 1372, 1991. (GWU 15371)

Blake*, D.; Allamandola*, L.; Sandford, S.; Hudgins, D.; Freund*, F.
Clathrate hydrate formation in amorphous cometary ice analogs in vacuo.
Science 254: 548-551, 1991. (GWU 14903)

- Fredericks, J.R.; Gibson*, E.K., Jr.; Hartmetz, C.P.
Trapped lunar volcanic gases within Apollo 15 glass spherules (Abstract).
Lunar and Planetary Science Conference XXII: 409-410, 1991. (GWU 12290)
- Freund*, F.; Battlo, F.; LeRoy, R.C.
Electrical conductivity of olivine revisited (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 529, 1991. (GWU 16096)
- Freund*, F.; Battlo, F.; LeRoy, R.C.; Lersky, S.; Masuda, M.M.; Chang*, S.
Crystal-field-driven redox reactions: How common minerals split H₂O and CO₂ into reduced H₂ and C plus oxygen (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 112, 1991. (NASA-CP-3129) (GWU 14564)
- Freund*, F.; Masuda, M.M.; Freund, M.M.
Highly mobile oxygen hole-type charge carriers in fused silica.
Journal of Materials Research 6(8): 1619-1622, 1991. (GWU 14874)
- Gibson*, E.K., Jr.; Hartmetz, C.P.
Carbon-bearing phases and volatiles in interplanetary dust particles (Abstract).
Lunar and Planetary Science Conference XXII: 439-440, 1991. (GWU 12291)
- Gibson*, E.K., Jr.; Hartmetz, C.P.
Volatile in interplanetary dust particles and aerogels (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 20, 1991. (NASA-CP-3129) (GWU 14035)
- Gibson, J.E.; Pillinger, C.T.; Gibson*, E.K., Jr.
Carbon content of silica aerogel: A material proposed as a medium for collection of cosmic dust grains (Abstract).
Lunar and Planetary Science Conference XXII: 441-442, 1991. (GWU 12288)
- Griffith, C.A.; Owen*, T.; Wagener, R.
Titan's surface and troposphere, investigated with ground-based, near-infrared observations.
Icarus 93(2): 362-378, 1991. (GWU 15375)
- Hartmetz, C.P.; Gibson*, E.K., Jr.; Blanford, G.E.
Analysis of volatiles present in interplanetary dust and stratospheric particles collected on large area collectors.
Proceedings of Lunar and Planetary Science 21: 557-567, 1991. (GWU 12287)
- Hartmetz, C.P.; Gibson*, E.K., Jr.; Blanford, G.E.
In situ extraction and analysis of volatile elements and molecules from carbonaceous chondrites.
Proceedings of Lunar and Planetary Science 21: 527-539, 1991. (GWU 15955)
- Herbst, E.; DeFrees*, D.J.; Talbi, D.; Pauzat, F.; Koch, W.; McLean, A.D.
Calculations on the rate of the ion-molecule reaction between NH₃⁺ and H₂.
Journal of Chemical Physics 94(12): 7842-7849, 1991. (GWU 5924)
- Hollis, J.M.; Snyder, L.E.; Ziurys, L.M.; McGonagle, D. (Irvine, W.M. = P.I.)
Interstellar HNO: Confirming the identification.
In: *Skylines* (Haschick, A.D., Ho, P.T.P., Eds.). San Francisco, CA: Astronomical Society of the Pacific, p. 407-412, 1991. (ASP Conference Series, Vol. 16) (GWU 15302)

Madden, S.C. (Irvine, W.M. = P.I.)
Results of a galactic survey for the ring molecule cyclopropenylidene (C_3H_2).
In: *Chemistry in Space* (Greenberg, J.M., Pirronello, V., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 437-438, 1991. (GWU 15290)

McConville, P.; Reynolds, J.H.; Epstein*, S.; Roedder, E.
Implanted 3He , 4He , and Xe in further studies of diamonds from Western Australia.
Geochimica et Cosmochimica Acta 55(7): 1977-1989, 1991. (GWU 15052)

Minh, Y.C.; Brewer, M.K.; Irvine*, W.M.; Friberg, P.; Johansson, L.E.B.
Abundance and chemistry of interstellar $HOCO^+$.
Astronomy and Astrophysics 244: 470-476, 1991. (GWU 14756)

Minh, Y.C.; Irvine*, W.M.
Interstellar H_2S : Probe of grain surface chemistry.
In: *Chemistry in Space* (Greenberg, J.M., Pirronello, V., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 435-436, 1991. (GWU 15263)

Minh, Y.C.; Irvine*, W.M.
Upper limits for the ethyl-cyanide abundances in TMC-1 and L134N: Chemical implications.
Astrophysics and Space Science 175: 165-169, 1991. (GWU 14754)

Minh, Y.C.; Irvine*, W.M.; Brewer, M.K.
 H_2CS abundances and ortho-to-para ratios in interstellar clouds.
Astronomy and Astrophysics 244: 181-189, 1991. (GWU 14753)

Minh, Y.C.; Ziurys, L.M.; Irvine*, W.M.; McGonagle, D.
Abundances of hydrogen sulfide in star-forming regions.
Astrophysical Journal 366: 192-197, 1991. (GWU 14755)

Notesco, G.; Kleinfeld, I.; Laufer, D.; Bar-Nun, A. (Owen, T. = P.I.)
Gas release from comets.
Icarus 89: 411-413, 1991. (GWU 13846)

Ohishi, M.; Kawaguchi, K.; Kaifu, N.; Irvine*, W.M.; Minh, Y.C.; Yamamoto, S.; Saito, S.
The ortho to para ratio for ketene in TMC-1.
In: *Atoms, Ions, and Molecules: New Results in Spectral Line Astrophysics* (Haschick, A.D., Ho, P.T.P., Eds.). San Francisco, CA: Astronomical Society of the Pacific, p. 387-391, 1991. (ASP Conference Series, Vol. 16) (GWU 14861)

Ohishi, M.; Suzuki, H.; Ishikawa, S.-I.; Yamada, C.; Kanamori, H.; Irvine*, W.M.; Brown, R.D.; Godfrey, P.D.; Kaifu, N.
Detection of a new carbon-chain molecule, CCO.
Astrophysical Journal 380: L39-L42, 1991. (GWU 14758)

Owen*, T.; Bar-Nun, A.; Kleinfeld, I.
Cometary impacts on the early Earth: Evidence from heavy noble gases (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 59, 1991. (GWU 16098)

Owen*, T.; Bar-Nun, A.; Kleinfeld, I.
Noble gases in terrestrial planets: Evidence for cometary impacts?
In: *Comets in the Post-Halley Era*, Volume 1 (Newburn, R.L., Jr., et al., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 429-437, 1991. (GWU 13845)

Pauzat, F.; Ellinger, Y.; McLean, A.D. (DeFrees, D.J.; Loew, G.H. = P.I.)
Is interstellar detection of higher members of the linear radicals C_nCH and C_nN feasible?
Astrophysical Journal 369: L13-L16, 1991. (GWU 12309)

Stone, J.; Hutcheon, I.D.; Epstein*, S.; Wasserburg, G.J.
Si, C and N isotopes in SiC from Orgueil and Murchison: H- and He- burning components in presolar grains
(Abstract).
Lunar and Planetary Science Conference XXII: 1337-1338, 1991. (GWU 15705)

Talbi, D.; DeFrees*, D.J.
Ab initio study of C + H₃⁺ reactions.
Chemical Physics Letters 179(1,2): 165-168, 1991. (GWU 14899)

Talbi, D.; DeFrees*, D.J.; Egolf, D.A.; Herbst, E.
Calculations concerning the reaction C + H₃⁺ → CH⁺ + H₂
Astrophysical Journal 374(1): 390-393, 1991. (GWU 7026)

Tarter*, J.; Saykally, R.
Measurement of the spectral signature of small carbon clusters at near and far infrared wavelengths (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 17, 1991. (NASA-CP-3129) (GWU 9080)

Tielens, A.G.G.M.; Allamandola*, L.J.; Sandford, S.A.
Laboratory, observational and theoretical studies of interstellar ices.
In: *Solid-State Astrophysics* (Bussoletti, E., Strazzulla, G., Eds.). Amsterdam, The Netherlands: North-Holland Publishing, p. 29-58, 1991. (GWU 14443)

Tielens, A.G.G.M.; Tokunaga, A.T.; Geballe, T.R.; Baas, F. (Allamandola, L.J. = P.I.)
Interstellar solid CO: Polar and nonpolar interstellar ices.
Astrophysical Journal 381: 181-199, 1991. (GWU 15973)

Trafton, L.M.; Lester, D.F.; Ramseyer, T.F.; Salama, F.; Sandford, S.A.; Allamandola*, L.J.
A new class of absorption feature in Io's near-infrared spectrum.
Icarus 89: 264-276, 1991. (GWU 14767)

Trice, J.P.; Becker, J.F.; Sauke, T.B.; Freund*, F.
Kinetic ¹²C/¹³C fractionation during isothermal degassing of arc-fusion grown magnesium oxide (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 523, 1991. (GWU 16097)

Ungerechts, H.; Bergin, E.A.; Carpenter, J.; Goldsmith, P.F.; Irvine*, W.M.; Lovell, A.; McGonagle, D.; Schloerb, F.P.; Snell, R.L.
Chemical gradients in the Orion Molecular Cloud (Abstract).
Bulletin of the American Astronomical Society 23(4): 1372, 1991. (GWU 15370)

Villar, H.O.; Loew*, G.H.
Properties of selective type-I benzodiazepine receptor ligands.
International Journal of Quantum Chemistry S18: 131-149, 1991.

Watson, L.L.; Ihinger, P.D.; Epstein*, S.; Stolper*, E.M.
Hydrogen, carbon and oxygen isotopic composition of volatiles in Nakhla (Abstract).
Lunar and Planetary Science Conference XXII: 1473-1474, 1991. (GWU 15706)

Whang, E.-J.; Freund*, F.
Carbon segregation from calcium oxide single crystals (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 530, 1991. (GWU 16094)

Prebiotic Evolution

Arrhenius*, G.

Sources and geochemical evolution of cyanide and formaldehyde (Abstract).

In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 44, 1991. (NASA-CP-3129) (GWU 8943)

Barak, D.; Shibata, M.; Rein*, R.

Structural investigation of protein kinase C inhibitors.

Journal of Molecular Structure 230: 419-429, 1991. (GWU 14780)

Benkert, J.P.; Kerridge*, J.F.; Kim, J.S.; Kim, Y.; Marti, K.; Signer, P.; Wieler, R.

Evolution of isotopic signatures in lunar-regolith nitrogen: Noble gases and N in ilmenite grain-size fractions from regolith breccia 79035 (Abstract).

Lunar and Planetary Science Conference XXII: 85-86, 1991. (GWU 15707)

Betts, J.N.; Holland*, H.D.

The oxygen content of ocean bottom waters, the burial efficiency of organic carbon, and the regulation of atmospheric oxygen.

Palaeogeography, Palaeoclimatology, Palaeoecology 97: 5-18, 1991. (GWU 14773)

Bishop, J.L.; Pieters, C.M.; Edwards, J.O.; Coyne*, L.M.; Chang*, S.

Spectroscopic analyses of Fe and water in clays. A Martian surface weathering study (Abstract).

Lunar and Planetary Science Conference XXII: 107-108, 1991. (GWU 15708)

Blank, J.G.; Stolper*, E.M.; Zhang, Y.

Diffusion of CO₂ in rhyolitic melt (Abstract).

Eos. Transactions, American Geophysical Union 72(17, Suppl.): 312, 1991. (GWU 16105)

Chu, B.C.F.; Orgel*, L.E.

Binding of hairpin and dumbbell DNA to transcription factors.

Nucleic Acids Research 19(24): 6958, 1991. (GWU 14665)

Chyba, C.; Sagan*, C.

Electrical energy sources for organic synthesis on the early Earth.

Origins of Life and Evolution of the Biosphere 21: 3-17, 1991. (GWU 14820)

Chyba, C.F. (Sagan, C. = P.I.)

The heavy bombardment and the origins of life (Abstract).

Eos. Transactions, American Geophysical Union 72(44, Suppl.): 59, 1991. (GWU 14818)

Chyba, C.F.; Sagan*, C.; Brookshaw, L.; Thomas, P.J.

Terrestrial accretion of prebiotic volatiles and organic molecules during the heavy bombardment.

In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 149-154, 1991. (GWU 14819)

Chyba, C.F.; Sagan*, C.; Thomas, P.J.; Brookshaw, L.

Terrestrial production vs. extraterrestrial delivery of prebiotic organics to the early Earth (Abstract).

In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 46, 1991. (NASA-CP-3129) (GWU 7666)

Coyne*, L.

Reflectance signature of trapped holes in montmorillonites using near infrared reflectance analysis (NIRA) and EPR. Paper presented at "Colloidal and Surface Chemistry of Clays," Amerian Chemical Society Symposium, Atlanta, GA, April 14-19, 1991.

Egli, M.; Williams, L.D.; Gao, Q.; Rich*, A.
Structure of the pure-spermine form of Z-DNA (magnesium free) at 1-Å resolution.
Biochemistry 30(48): 1388-1402, 1991. (GWU 14961)

Egli, M.; Williams, L.D.; Gao, Q.; Rich*, A.
X-ray crystal structures of nucleic acids and their complexes with mono and bis-intercalators (Abstract).
Journal of Biomolecular Structure and Dynamics 8(6): a047, 1991. (GWU 16006)

Ferris*, J.P.; Guillemin, J.C.
Photochemical reactions of cyanoacetylene and dicyanoacetylene: Possible processes in Titan's atmosphere (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 42, 1991. (NASA-CP-3129) (GWU 14162)

Fox*, S.W.
Nonrandom protein in prelife → life transition (Abstract).
In: *Abstracts, Annual Meeting of the American Association for the Advancement of Science*, Washington, DC, February 14-19, 1991, p. 67. (GWU 14853)

Fox*, S.W.
Origins of life and biomedicinals from thermal proteins (Abstract).
Abstract of paper presented at the 201st National Meeting of the American Chemical Society, Biopolymers Symposium, Atlanta, GA, April 18-19, 1991, 1 p. (GWU 15073)

Fox*, S.W.
Synthesis of life in the lab? Defining a protoliving system.
Quarterly Review of Biology 66(2): 181-185, 1991. (GWU 5908)

Fox*, S.W.; Bahn, P.R.
Self-sealing artificial skin comprising copoly-alpha-amino acid (Patent).
U.S. Patent No. 4,996,292, February 26, 1991.

Fox*, S.W.; Ruecknagel, P.; Braunitzer, G.
Molecular bases for unity and diversity in organic evolution (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 55, 1991. (NASA-CP-3129) (GWU 12307)

Gao, Q.; Williams, L.D.; Egli, M.; Rabinovich, D.; Chen, S.-L.; Quigley, G.J.; Rich*, A.
Drug-induced DNA repair: X-ray structure of a DNA-ditercalinium complex.
Proceedings of the National Academy of Sciences USA 88(6): 2422-2426, 1991. (GWU 15260)

Harada, K.; Orgel*, L.E.
The cyclization of arabinosyladenine-5'-phosphorimidazolide.
Journal of Molecular Evolution 32: 358-359, 1991. (GWU 12608)

Harang, E.A.; Baltscheffsky, H.; Deamer*, D.W.
Production of ATP and PPi in *R. rubrum* chromatophores using ferrocyanide illumination to produce chemiosmotic proton gradients (Abstract).
Biophysical Journal 59: 518a, 1991. (GWU 14854)

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Promotion of neuronal survival in vitro by thermal proteins and poly(dicarboxylic) amino acids.
Brain Research 541: 273-283, 1991. (GWU 12292)

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Catalysis of hydrolysis and nucleophilic substitution at the P-N bond of phosphoimidazolide-activated nucleotides in phosphate buffers.
Journal of Organic Chemistry 56(4): 1513-1521, 1991. (GWU 14747)

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The structural studies of endotoxin neutralizing protein (Abstract).
Journal of Biomolecular Structure and Dynamics 8(6): a097, 1991. (GWU 16001)

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Interstellar precursors in synthesis of meteoritic organic matter (Abstract).
Meteoritics 26(4): 356-357, 1991. (GWU 14905)

Kerridge*, J.F.
Isotopic analysis of cometary organic matter.
Space Science Reviews 56(1-2): 177-184, 1991. (GWU 15257)

Kerridge*, J.F.
Isotopic constraints on the origin of meteoritic organic matter (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 37, 1991. (NASA-CP-3129) (GWU 13377)

Kerridge*, J.F.; Bochsler, P.; Eugster, O.; Geiss, J.
Modelling the evolution of N and $^{15}\text{N}/^{14}\text{N}$ in the lunar regolith (Abstract).
Lunar and Planetary Science Conference XXII: 711-712, 1991. (GWU 15709)

Khare*, B.N.; Thompson, W.R.; Cheng, L.; Sagan*, C.; Meisse, C.; Arakawa, E.T.; Matthews, C.N.
Optical properties of tholin from $\text{H}_2\text{O/C}_2\text{H}_6$ (6:1) ice, and comparison with Titan tholin, kerogen and meteoritic organics (Abstract).
Bulletin of the American Astronomical Society 23(3): 1186, 1991. (GWU 14814)

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Optical constants of kerogen from 0.15 to 40 μm : Comparison with meteoritic organics.
In: *Origin and Evolution of Interplanetary Dust* (Levasseur-Regourd, A.C., Hasegawa, H., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 99-101, 1991. (GWU 14817)

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Stereoselective formation of bis(α -aminoacyl) esters of 5'-AMP suggests a primitive peptide synthesizing system with a preference for L-amino acids.
Biochimica et Biophysica Acta 1076: 395-400, 1991. (GWU 12269)

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Chemistry of aminoacylation of 5'-AMP and the origin of protein synthesis (Abstract).
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Icarus 89(2): 377-383, 1991. (GWU 15382)

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The biosphere as a driver for global atmospheric change.
In: *Scientists on Gaia* (Schneider, S.H., Boston, P.J., Eds.). Cambridge, MA: MIT Press, p. 353-361, 1991. (GWU 14811)

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A window in time for the first evolutionary radiation (Abstract).

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Evolution of Advanced Life

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Appendix

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Principal Investigators

Louis J. Allamandola
NASA, Ames Research Center
Mail Stop 245-6
Moffett Field, CA 94035

Vincent Anicich
NASA, Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109

Gustaf Arrhenius
Scripps Institution of Oceanography
Mail Code A-020
University of California, San Diego
La Jolla, CA 92093

Frank Asaro
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Stanley M. Awramik
Department of Geological Sciences
University of California
Santa Barbara, CA 93106

Amos Banin
San Francisco State University
Foundation
1640 Holloway Avenue
San Francisco, CA 94132

Albert Betz
Space Sciences Laboratory
University of California
Berkeley, CA 94720

John Billingham
NASA, Ames Research Center
Mail Stop 239-22
Moffett Field, CA 94035

David F. Blake
NASA, Ames Research Center
Planetary Biology Branch
Mail Stop 239-4
Moffett Field, CA 94035

Geoffrey A. Blake
Division of Geological
and Planetary Sciences
California Institute of Technology 17-25
Pasadena, CA 91125

Robert E. Blankenship
Center for the Study of Early Events
in Photosynthesis
Arizona State University
Tempe, AZ 85287

Stuart Bowyer
Department of Astronomy
Space Sciences Laboratory
University of California
Berkeley, CA 94720

John C. Briggs
1260 Julian Drive
Watkinsville, GA 30677

Bob Buchanan
College of Natural Resources
Department of Plant Biology
University of California
Berkeley, CA 94720

Theodore Bunch
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

Donald E. Canfield
Department of Earth
and Atmospheric Sciences
Georgia Institute of Technology
Atlanta, GA 30332

Glenn Carle
NASA, Ames Research Center
Mail Stop 239-12
Moffett Field, CA 94035

Sherwood Chang
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

Principal Investigators

Heinrich D. Holland

Department of Earth & Planetary Sciences
Hoffman Laboratory
Harvard University
20 Oxford Street
Cambridge, MA 02138

Marsha Hollander

Department of Chemistry
George Mason University
4400 University Drive
Fairfax, VA 22030

John R. Holloway

Departments of Chemistry and Geology
Arizona State University
Tempe, AZ 85287

William M. Irvine

Five College Radio Astronomy
Observatory
University of Massachusetts
619 Lederle Graduate Research Center
Amherst, MA 01003

Linda Jahnke

NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

Thomas H. Jukes

Space Science Laboratory
University of California
6701 San Pablo Avenue
Oakland, CA 94608

Anastassia Kanavarioti

Department of Chemistry
University of California
Santa Cruz, CA 95064

James F. Kasting

Department of Geological Sciences
503 Deike Building
Pennsylvania State University
University Park, PA 16802

John F. Kerridge

Institute of Geophysics
and Planetary Physics
University of California
405 Hilgard Hall
Los Angeles, CA 90024

Bishun N. Khare

Laboratory for Planetary Studies
Center for Radiophysics
and Space Research
Space Sciences Building
Cornell University
Ithaca, NY 14853

Andrew H. Knoll

Botanical Museum
Harvard University
26 Oxford Street
Cambridge, MA 02138

Daniel R. Kojiro

NASA, Ames Research Center
Mail Stop 239-12
Moffett Field, CA 94035

Robert Kretsinger

Department of Biology
University of Virginia
Charlottesville, VA 22901

James C. Lacey, Jr.

Department of Biochemistry
Room 520 CHSB
University of Alabama
Birmingham, AL 35294

Janos K. Lanyi

Department of Physiology
and Biophysics
California College of Medicine
University of California
Irvine, CA 92717

James G. Lawless

NASA, Ames Research Center
Mail Stop 242-4
Moffett Field, CA 94035

Principal Investigators

Margaret Race
College of Natural Resources
101 Giannini Hall
University of California
Berkeley, CA 94720

Michael R. Rampino
Department of Applied Science
26-36 Stuyvesant Street
New York University
New York, NY 10003

David M. Raup
Department of Geophysical Sciences
University of Chicago
5734 South Ellis Avenue
Chicago, IL 60637

Robert Rein
Roswell Park Memorial Institute
Building CCC, Suite 218
666 Elm Street
Buffalo, NY 14263

Alexander Rich
Department of Biology
Massachusetts Institute of Technology
Cambridge, MA 02139

L.J. Rothschild
NASA, Ames Research Center
Mail Stop 245-3
Moffett Field, CA 94035

Jonathan Roughgarden
Department of Biological Sciences
Stanford University
Stanford, CA 94305

Ted L. Roush
NASA, Ames Research Center
Mail Stop 245-3
Moffett Field, CA 94035

John D. Rummel
Program Manager, Exobiology
NASA Headquarters
Code SBR
Washington, DC 20546

Carl Sagan
Center for Radiophysics
and Space Research
Laboratory for Planetary Studies
Space Sciences Building
Cornell University
Ithaca, NY 14853

Thomas Scattergood
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

J. William Schopf
Department of Earth & Space Sciences
3806 Geology Building
University of California
Los Angeles, CA 90024

J. John Sepkoski, Jr.
Department of Geophysical Sciences
University of Chicago
5734 South Ellis Avenue
Chicago, IL 60637

Thomas C. Shen
NASA, Ames Research Center
Mail Stop 239-12
Moffett Field, CA 94035

Edward M. Stolper
Professor of Geology
California Institute of Technology
Pasadena, CA 91125

Jill Tarter
NASA, Ames Research Center
Mail Stop 239-22
Moffett Field, CA 94035

Peter Tsou
California Institute of Technology
NASA, Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

David Usher
Department of Chemistry
Baker Laboratory
Cornell University
Ithaca, NY 14853

Principal Investigators

SETI Investigators

**NASA, Ames Research Center
SETI Project
Mail Stop 244-11
Moffett Field, CA 94035**

**NASA, Jet Propulsion Laboratory
SETI Program
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109**

**Peter Backus
David H. Brocker
D. Kent Cullers
L.J. Deutsch
John Dreher
Chris Hlavka
J.L. Huntington
Jane Jordan
J.R. Marshall
D.E. Schwartz
Richard Stauduhar
L.D. Webster**

**P. Asmar
D.J. Burns
M.J. Flanagan
C.F. Foster
M.F. Garyantes
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